REMARKS

Applicants have amended their drawings figures to add the legend "BACKGROUND" to Fig. 1. In view of this amendment to Fig. 1, it is respectfully submitted that the requirement for designation of Fig. 1, set forth in Item 1 on page 2 of the Office Action mailed May 8, 2007, has been satisfied.

Applicants have amended their claims in order to further clarify the definition of various aspects of the present invention. Specifically, Applicants have amended their claims to consistently recite "at least one" incident light waveguide (A), and "at least one" optical waveguide (a). In view of these amendments to the claims, including claims 1 and 2, it is respectfully submitted that the objection to claims 1 and 2 as set forth in Item 2 on page 2 of the Office Action mailed May 8, 2007, is moot, and that the required correction has been made. Applicants have further amended claims 1 and 2 to recite that the at least one optical waveguide (a) has a curved structure, consistent with the description, for example, in the paragraph bridging pages 3 and 4, as well as in Example 1 on pages 30 and 31, and Examples 2-4 on pages 32-35, of Applicants' specification.

In addition, Applicants are adding new claims 19-28 to the application. Of these newly added claims, claims 19 and 20 are directed to a light branching optical waveguide, and claims 21-28 are directed to a method of manufacturing a light branching optical waveguide.

Claims 19 and 20, dependent respectively on claims 1 and 19, numerically define an offset distance between the extended line of the geometrical central axis of the at least one optical waveguide (a) and the geometrical central axis of the multi-mode optical waveguide, consistent with the description in the paragraph bridging pages 15 and 16 of Applicants specification.

New independent claim 21 defines a method of manufacturing a light branching optical waveguide, using at least one incident light waveguide (A), optically connected to one end of a multi-mode optical waveguide, and output light waveguides (B) larger in number than the number of incident light waveguides (A), optically connected to the other end of the multi-mode optical waveguide, with the at least one incident light waveguide (A) including at least one optical waveguide (a) having an intensity distribution of light entering the multi-mode optical waveguide therefrom that is asymmetric with respect to a geometrical central axis of this at least one optical waveguide (a), this method including positioning the at least one optical waveguide (a) such that an extended line of the geometrical central axis of the at least one optical waveguide (a) does not coincide with a geometrical central axis of the multi-mode optical waveguide. In connection with claim 21, note claim 1. Claim 22, dependent on claim 21, recites that the at least one optical waveguide (a) is a curved optical waveguide; and claims 23 and 24, dependent respectively on claims 22 and 21, recite that the at least one incident light waveguide (A) is one incident light waveguide (A), the at least one optical waveguide (a) is one optical waveguide (a), and the output light waveguides (B) are two in number.

Independent claim 25 recites a method of manufacturing a light branching optical waveguide, utilizing the waveguides (A), (B) and (a), and the multi-mode optical waveguide, as discussed previously in connection with claim 21, the method including forming a core shape of the multi-mode optical waveguide to be asymmetric with respect to a geometrical central axis of the multi-mode optical waveguide. In connection with claim 25, note claim 2. Claims 26-28 recite the same subject matter expressly set forth in claims 22, 23 and 24, but are dependent respectively on claims 25, 26 and 25.

Noting correspondence between the subject matter of claims 21-28, on the one hand, and the previously considered waveguide claims, including claims 1 and 2, it is respectfully submitted that claims 21-28 should be considered on the merits in the above-identified application, notwithstanding that these claims are directed to a different statutory class of subject matter than previously considered claims.

Applicants respectfully traverse the rejection of claims 1-18 under the first and seconds paragraphs of 35 USC 112, respectively as failing to comply with the enablement requirement and as being incomplete for omitting essential elements, these rejections being set forth respectively in Items 4 and 6 on pages 2 and 3 of the Office Action mailed May 8, 2007. Thus, claims 1 and 2 have been amended to recite that the at least one optical waveguide (a) has a curved structure. It is respectfully submitted that this curved structure of the at least one optical waveguide (a) causes the asymmetric intensity distribution of light at the location where the at least one optical waveguide (a) and the multi-mode optical waveguide are connected. In this regard, and as will be discussed further infra, it is respectfully submitted that the present invention solves the problem due to the intensity distribution of light is asymmetric at such location where the at least one optical waveguide (a) and the multi-mode optical waveguide are connected, providing that the branching ratio between the quantities of light branched into the (at least) two output light waveguides (B) being equal can be achieved where the output light waveguides (B) and the multi-mode optical waveguide are connected, by changing ("correcting") asymmetric light to symmetric light.

In any event, it is respectfully submitted that in reciting in each of claims 1 and 2 that the at least one optical waveguide (a) has a curved structure, Applicants clearly set forth an enabling disclosure as to structure causing the intensity distribution of light to be asymmetric; and, in view thereof, clearly avoids bases as

set forth by the Examiner in Items 4 and 6 on pages 2 and 3 of the Office Action mailed May 8, 2007, for the rejections under the first and second paragraphs of 35 USC 112.

As for newly added claims 21-28, these claims recite a method of changing an asymmetric light in a waveguide to a symmetric light, specifying the waveguide having such an asymmetric intensity distribution of light. It is respectfully submitted that the method claims clearly satisfy both the first and second paragraphs of 35 USC 112, with respect to a method of changing an asymmetric light in a waveguide to a symmetric light.

Applicants respectfully submit that all of the claims presented for consideration by the Examiner patentably distinguish over the teachings of the prior art applied by the Examiner in rejecting claims in the Office Action mailed May 8, 2007, that is, the teachings of U.S. Patent No. 6,236,784 to Ido, under the provisions of 35 USC 102 and 35 USC 103.

It is respectfully submitted that this reference as applied by the Examiner would have neither taught nor would have suggested such light branching optical waveguide, or such optical device having such light branching optical waveguide, as in the present claims, including, inter alia, wherein the waveguide includes at least one incident light waveguide (A) optically connected to one end of a multi-mode optical waveguide and output light waveguides (B) larger in number than the incident light waveguide(s), optically connected to the other end thereof, wherein an intensity distribution of light entering from at least one optical waveguide (a), of the at least one incident light waveguide (A), into the multi-mode optical waveguide at a connecting surface of the at least one incident light waveguide (A) and the multi-mode optical waveguide, is asymmetric with respect to a geometrical central axis of the waveguide (a), the at least one optical waveguide (a) having a curved structure,

and (i) an extended line of the geometrical central axis of the at least one optical waveguide (a) does not coincide with a geometrical central axis of the multi-mode optical waveguide (see claims 1 and 3), and/or (ii) a core shape of the multi-mode optical waveguide is asymmetric with respect to a geometrical central axis of the multi-mode optical waveguide (see claim 2).

Furthermore, it is respectfully submitted that the reference as applied by the Examiner would have neither taught nor would have suggested such a method of manufacturing a light branching optical waveguide, having apparatus including the waveguides (A), (B) and (a), and the multi-mode optical waveguide, as discussed previously, the method including positioning the at least one optical waveguide (a) such that an extended line of the geometrical central axis of the at least one optical waveguide (a) does not coincide with a geometrical central axis of the multi-mode optical waveguide (see claim 21); or wherein the method includes forming a core shape of the multi-mode optical waveguide to be asymmetric with respect to a geometrical central axis of the multi-mode optical waveguide (see claim 25).

Furthermore, it is respectfully submitted that the teachings of the applied reference would have neither disclosed nor would have suggested such light branching optical waveguide as in the present claims, having features as discussed previously in connection with claims 1-3, and, additionally, having features as in the dependent claims, dependent ultimately on claims 1 and 2, including, inter alia, wherein an optical central axis having a peak intensity in the intensity distribution of light entering into the multi-mode optical waveguide from the at least one optical waveguide (a) substantially coincides with the geometrical central axis of the multi-mode optical waveguide (see claims 4 and 12); and/or wherein the core shape of the multi-mode optical waveguide has a notch at at least one of its side edges (see claims 5 and 13), particularly wherein such notch is obtained by a technique as in

claims 6 and 14, especially with a shape of the notch as in claims 6 and 14; and/or wherein the at least one incident light waveguide (A) includes one incident light waveguide and the output light waveguides (B) include at least two output light waveguides, with a branching ratio between quantities of light branched into the at least two respective output light waveguides (B) being substantially equal (see claims 7 and 15); and/or wherein at least one of the at least one incident light waveguide (A) and the output light waveguides (B) include a single-mode optical waveguide (note claims 8 and 16); and/or materials of the core or clad of the multi-mode optical waveguide, as set forth in claims 9, 10 and 17; and/or offset distance between the extended line of the geometrical central axis of the optical waveguide and the geometrical central axis of the multi-mode optical waveguide, as in claims 19 and 20.

In addition, it is respectfully submitted that the teachings of the applied reference would have neither disclosed nor would have suggested such a method as discussed previously in connection with claims 21 and 25, and including additional features as in claims dependent on claims 21 and 25, including (but not limited to) wherein the at least one optical waveguide (a) is a curved optical waveguide (see claims 22 and 26); and/or wherein the at least one incident light waveguide (A) is one incident light waveguide (A), the at least one optical waveguide (a) is one optical waveguide (a), and the output light waveguides are at least two in number (see claims 23, 24, 27 and 28).

The present invention is directed to a light branching optical waveguide and optical device using the same, as well as a method of manufacturing such light branching optical waveguide. Such waveguide and device are used in optical transmission systems, and there has been a growing demand for such systems with the recent widespread use of personal computers and the internet.

An optical branching circuit and an optical multiplexing circuit serving as basic elements are indispensable to an integrated optical circuit, and an optical waveguide branched to provide a Y shape has been conventionally known. However, problems arise in connection with reducing light loss in integrated optical circuits, while reducing the size of the circuit. For example, note the paragraph bridging pages 3 and 4 of Applicants' specification, describing that when the optical waveguide has a curved structure, e.g., advantageous for reducing size of the structure, asymmetry occurs, causing a problem as described in this paragraph bridging pages 3 and 4 of Applicants' specification. Note also the sole full paragraph on page 4, the paragraph bridging pages 4 and 5, the paragraph bridging pages 5 and 6, and the first two paragraphs on page 6, of Applicants' specification, describing additional problems arising in connection with other previously known Y-branch optical waveguides.

Against this background, Applicants provide structure wherein a low-loss light branching optical waveguide is achieved, having reduced branch loss and a reduced variation in branching ratio, in a device which is relatively small (e.g., has a reduced size in view of use of curved waveguides).

As one feature of the present invention, Applicants have found that by providing structure wherein an optical waveguide (a) has a curved structure, whereby the optical waveguide (a) has an asymmetric distribution of light, and wherein an extended line of the geometrical central axis of the optical waveguide (a) having the asymmetric intensity distribution of light, into a multi-mode optical waveguide, does not coincide with a geometrical central axis of the multi-mode optical waveguide, objectives according to the present invention are achieved. See the last full paragraph on page 7 of Applicants' specification.

As another feature of the present invention, the present inventors have found that a branch loss and variation in branching ratio can be suppressed, irrespective of

wavelength of the light, by matching the wavelength dependence of a field distribution generated by shifting the geometrical central axis of an incident light waveguide and the geometrical central axis of a multi-mode optical waveguide to the wavelength dependence of a field distribution generated by making the core shape of the multi-mode optical waveguide asymmetric with respect to the geometrical central axis of the multi-mode optical waveguide. Note the paragraph bridging pages 7 and 8 of Applicants' specification. See also the paragraph bridging pages 20 and 21 thereof.

Thus, note that the multi-mode optical waveguide has a function of achieving the branching of light to a branching ratio of 1:1 (equal) in the case that the light exhibits symmetry in the incident waveguide. So, it is important to change asymmetric light of the optical waveguide (a) to a symmetric light. A problem to be solved by the present invention is changing an asymmetric light caused by optical waveguide (a) to symmetric light. This problem is solved by the present invention; i.e., by providing the branching ratio between the quantities of light branched into the two output light waveguides to be substantially equal, this means that the intensity distribution of light has been changed to symmetrical distribution.

Ido discloses an optical waveguide and a light wave circuit, including an asymmetric Y branch optical waveguide, which includes an input waveguide for entering light therein, two output waveguides for outputting the light therefrom, and a multi-mode waveguide which is disposed between the input waveguide and the two output waveguides and generates a plurality of mode lights therefrom, and wherein the multi-mode waveguide is made asymmetric with respect to a center line extending in the direction of an optical axis. Note, in particular, column 2, lines 52-60. Note also the paragraph bridging columns 2 and 3 of this patent. This patent discloses a further embodiment wherein the asymmetric Y branch optical waveguide

includes an input waveguide for entering light therein, two output waveguides for outputting the light therefrom, and a multi-mode waveguide which is disposed between the input and two output waveguides and generates a plurality of mode lights therefrom, with distances between sides of core portions of the multi-mode waveguide and a center line differing from each other at least at a portion with respect to the direction of traveling of the light. See column 3, lines 7-17. Note also column 9, lines 34-47 of this patent.

It is respectfully submitted that the Y-branch optical waveguide in Ido has a first optical waveguide (waveguide for input) in which the intensity distribution of light is symmetric, and second optical waveguides (waveguides for output) in which the intensity distribution of light is asymmetric.

In contrast, according to the apparatus of the present structure, and as in all of the present claims, the optical waveguide (a) has an asymmetric intensity distribution of light; and, more specifically, in the claimed device the optical waveguide (a) has a curved structure so that it can provide compact-sized circuits, this curved structure causing asymmetric intensity distribution of light at the portion where the optical waveguide (a) and the multi-mode optical waveguide are connected. According to the present invention, the intensity distribution of light is changed from asymmetric at the connecting surface between incident light waveguide (A) and the multi-mode optical waveguide, and the branching ratio between the quantities of light branched into the output optical waveguides (B) is equal (e.g., 1:1) at the portion where the optical output waveguides (B) and the multi-mode optical waveguide are connected, due to the present invention correcting asymmetric light to symmetric light.

Thus, while in Ido, the input optical waveguide has an intensity distribution of light that is symmetric and an optical waveguide for output in which the intensity of

distribution of light is asymmetric, according to the present invention the intensity distribution of light is asymmetric at the input portion and is symmetric at the output of the multi-mode optical waveguide, opposite to that of Ido.

Clearly, Ido would have neither taught nor would have suggested, and in fact would have taught away from, the presently claimed structure and method.

The contention by the Examiner in the last paragraph on page 4 of the Office Action mailed May 8, 2007, that the intensity distribution of light is a method limitation in an apparatus claim, is respectfully traversed. It is respectfully submitted that such intensity distribution of light is a characteristic (property) of the waveguide, and thus must be considered in the apparatus claims.

Moreover, Applicants respectfully traverse the contention by the Examiner in the last three lines on page 4 of the Office Action mailed May 8, 2007, that Ido teaches a structure that is identical to the claimed structure; as shown in the foregoing, it is respectfully submitted that the structure of Ido is different from the presently claimed apparatus, including in connection with the property of intensity distribution of light in waveguides thereof, and it is respectfully submitted that Ido would have neither taught nor would have suggested the presently claimed structure. Moreover, it is respectfully submitted that Ido would not have disclosed or suggested the curved structure of the optical waveguide (a) of the incident light waveguide (A), providing asymmetric distribution, as in the present claims.

Similarly, Applicants respectfully traverse the contention by the Examiner in the first paragraph on page 5 of the Office Action mailed May 8, 2007, with respect to a method recitation in an apparatus claim. Contrary thereto, it is respectfully submitted that recitations in the present claims are directed to characteristics or properties of the claimed structure, and must be considered in determining patentability thereof.

Applicants note contentions by the Examiner in connection with claim 2, as set forth on page 5 of the Office Action mailed May 8, 2007. The Examiner does not even refer to the at least one optical waveguide (a) as in claim 2; and, in particular, the recitation that an intensity distribution of light entering from at least one optical waveguide (a), of the at least one incident light waveguide (A), into the multi-mode optical waveguide at a connecting surface of the at least incident light waveguide (A) and the multi-mode optical waveguide, is asymmetric with respect to a geometrical central axis of the at least one optical waveguide (a), claim 2 now also reciting that the at least one optical waveguide (a) has a curved structure. Properly considering all of claim 2, including the at least one optical waveguide (a), it is respectfully submitted that Ido would have neither taught nor would have suggested the aspect of the present invention as in claim 2, and advantages thereof.

It is respectfully submitted that Ido would have neither disclosed nor would have suggested the subject matter of claim 3. Thus, claim 3 recites that an extended line of the geometrical central axis of the at least one optical waveguide (a) does not coincide with the geometrical central axis of the multi-mode optical waveguide. Note claim 1. As discussed previously, it is respectfully submitted that Ido does not disclose the extended line as in the last two lines of claim 1, or the core shape as in the last two lines of claim 2, in an optical waveguide having the at least one optical waveguide (a) having a curved structure. Clearly Ido would not have taught nor would have suggested structure having both such core shape and extended line, as in claim 3, and advantages thereof.

Furthermore, it is respectfully submitted that the teachings of Ido would have neither disclosed nor would have suggested the manufacturing process as in newly added claims 21-28, including the positioning of the at least one optical waveguide

(a) and the forming of the core shape of the multi-mode optical waveguide, as in claims 21 and 25, and advantages thereof as discussed previously.

In view of the foregoing comments and amendments, reconsideration and allowance of all claims remaining in the application are respectfully requested.

To the extent necessary, Applicants hereby petition for an extension of time under 37 CFR 1.136. Kindly charge any shortage of fees due in connection with the filing of this paper, including any extension of time fees, to the Deposit Account of Antonelli, Terry, Stout & Kraus, LLP, Account No. 01-2135 (case 396.45472X00), and please credit any overpayments to such Deposit Account.

Respectfully submitted,

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Enclosure: Replacement Sheet 1/4 (Figs. 1-3)

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